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A NEW RECORDING AND INTERPRETATION OF THE ROCK ART OF ANGONO, RIZAL, PHILIPPINES

Andrea Jalandoni and Paul S. C. Taçon

Abstract. The rock art of Angono is the most famous and controversial rock art site in the Philippines. It has been 50 years since the rock art was discovered, studied and interpreted. This paper identifies two phases of rock art production and uses 3D modelling and Geographic Information System (GIS) enhancements to corroborate the interpretation. Furthermore, by digitally tracing the figures we have produced a more accurate and complete record of the rock art. The digital record allows for statistical descriptions and interpretations previously not available, as well as providing a baseline for monitoring the rock art at the site.

Introduction

In the Philippines there are over twenty known rock painting and petroglyph sites (e.g. Novellino 1999; Peralta 2000; Jenkins 2007; Faylona et al. 2016; Jalandoni and Kottermair in press). Occasionally new sites are located, including in late 2016 in Masbate (GMA News Online 2016). The most famous and controversial of all Philippine rock art sites is the Angono Petroglyph Site, which is the first engraving site found in the Philippines. Most fieldwork at Angono, including rock art recording and excavation, was conducted in the 1960s and 1990s. Peralta (1973) recorded 127 discernible petroglyphs describing them as anthropomorphous. However, using 3D modelling and GIS tools to enhance the petroglyphs, we recorded 179 figures, including 113 anthropomorphs.

In this paper we report the results of fieldwork undertaken at Angono in February 2016 as part of the lead author's PhD research. We identify two phases of rock art production at Angono, present results of low-cost photogrammetry 3D modelling and Geographic Information System (GIS) tools for enhancing petroglyphs, explore some misconceptions of the rock art and discuss the difficulty of dating the rock art at Angono, Rizal.

Background information

The municipality of Angono, Rizal is known as the 'Art Capital of the Philippines' (*The Philippine Star* 2015). The Angono petroglyphs are located in a rockshelter east of the town and north of Laguna de Bai, the largest lake in the Philippines (Fig. 1). The topography consists of valleys and mountains and the Sierra Madre Range is in the east. The average annual rainfall of the area is 2223 mm and the average temperature is 27.2°C (Climate-Data.Org 2016). Geologically, the rock art is engraved on Guadalupe Tuff, described as fine-grained, brownish to 'buff-colored' tuff (De La Rosa n.d.: 8). De La Rosa (n.d.: 10) asserts the rockshelter is geologically

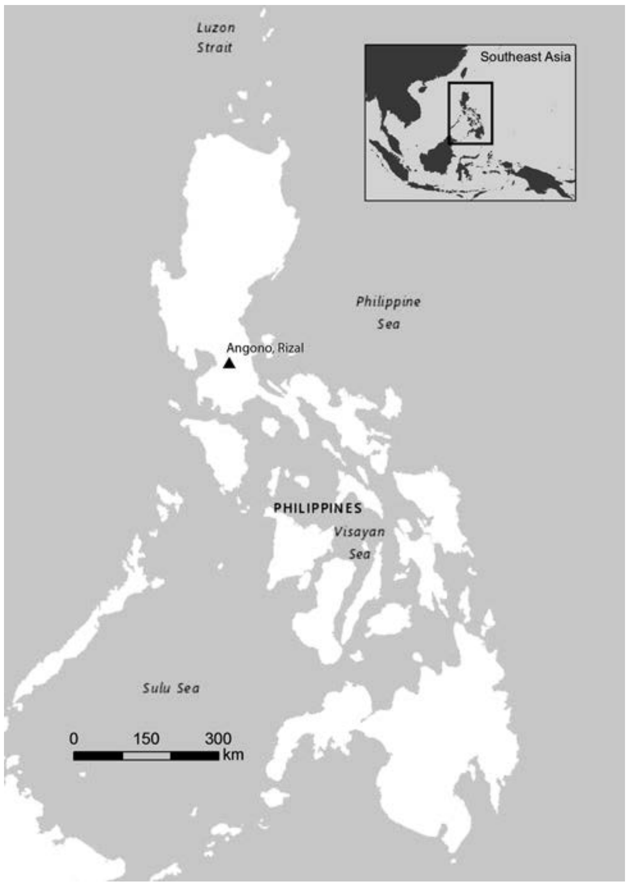

Figure 1. *Overview map of the Philippines with the location of Angono, Rizal. Source AJ.*

'young' and formed as recently as the late Pleistocene or early Holocene. Angono was discovered in 1965 by Carlos V. Francisco. Although it was declared a National Cultural Treasure in 1973 under Presidential Decree No. 260, the deterioration of the site has been brought to public attention (France-Presse 2014). When the World Monuments Watch program was launched in 1996, the Angono Petroglyphs and Borobudur were the only two Island Southeast Asian sites included (World Monuments Fund 1996).

The same year as discovery, excavations were carried out at the Angono rockshelter by Evangelista et al. (1965). The shelter was locally called *Mantandang Yungim* (Bautista 1998), but is now widely known as the Angono Rockshelter or Angono Petroglyph Rockshelter. Excavation within the rockshelter was aborted when it was determined there was no accumulation, but in fact, the floor was eroding away (Peralta 1973). Excavations at the edge of the cave floor yielded ceramic sherds, two obsidian flakes, 2 chert flakes, and shallow (2 cm below surface) charcoal, while surface digging outside the cave unearthed a polished stone adze and chert (Evangelista et al. 1965). The 1965 research team attempted to cast the petroglyphs. In the process, some of the rock was unintentionally extracted and vestiges of plaster are still visible as fill within the petroglyphs. Graffiti and vandalism also started at this time (Peralta 1973; Stanley-Price 1997), presumably because of the fascination of being the first petroglyph site in the Philippines.

In 1998, Bautista from the National Museum of the Philippines (NM) led an excavation to gain more information on the petroglyphs. The artefacts recovered were a corroded bullet and 4 pieces of petrified wood (Bautista 1998). Likewise, the flotation results showed insignificant amounts of charred material and organic fragments (Paz 1998). Bautista (1998) admits the effort failed to provide any information for dating the petroglyphs, but recommended further excavation. The corroded bullet is noteworthy because it supports accounts of Filipino guerillas occupying the rock shelter during World War II (Peralta 1973: 30).

Peralta (1973: 24, 46) clearly states no association was found between the artefacts and the petroglyphs. However, based on the presence of archaeological material, such as earthenware ceramics, obsidian flakes and stone tools found in the rockshelter, absence of metal and porcelain, and that the petroglyphs do not appear to have been made with a metal tool, he admits the possibility of a relationship between the makers of the rock art and the owners of the tools (Peralta 1973: 48–19). If they are associated, then the rock art might date 'prior to the introduction of metals into the country, that is the Neolithic Age, in what may be at least a millennium before the birth of Christ' (Peralta 1997, as cited in Stanley-Price 1997). Barretto-Tesoro (2008) is critical of the date and insists further research needs to be conducted, especially since the excavation of Bautista (1998) and pollen analysis of Paz (1998) proved futile. Peralta (1973: 47–49, 143) proposed the *terminus ante quem* for the petroglyphs would be when the Spaniards arrived in the Laguna de Bai area because they stopped many cultural practices wherever they evangelised.

Peralta's (1973) MA thesis incorporated the excavation work of 1965. He recorded 127 discernible petroglyphs classified into 51 types of figures (or motifs) representing 78 of the total number of petroglyphs, and 49 indeterminate or abstract petroglyphs in the rockshelter. He suggested the rock engravings were a result of sympathetic magic; for example, the petroglyphs he proposed represented children were made to transfer sickness to the rock (Peralta 1973: 92, 132). He also suggested the anthropomorphs were depicted for ritual (Peralta 2000: 63).

Figure 2. *Angono Rockshelter and viewing platform with remnants of 1990s green fence visible. Source PT.*

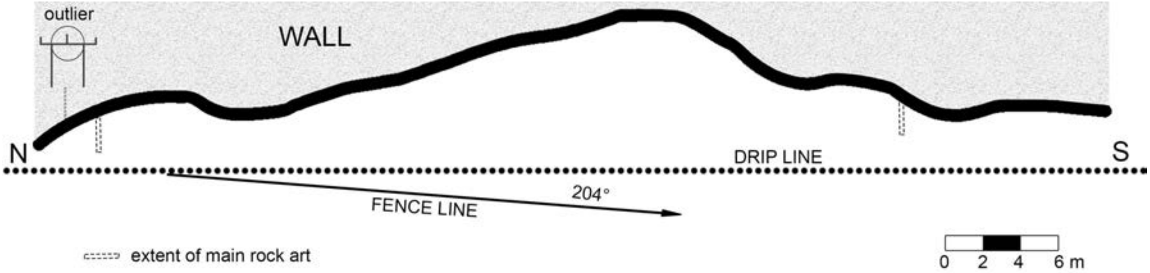

***Figure 3.** Plan view of Angono Rockshelter. Source PT and AJ.*

Methods

The site was visited by the authors from 5–9 February 2016. Fieldwork consisted of taking photographs to create 3D models, interviewing locals, experimenting with various materials in relation to rock art production and exploring nearby caves for possible rock art.

Dimensions and orientation

According to Peralta (1972), the Angono rockshelter measured 62.84 metres in length, with the majority of the rock art within a 48 m stretch of wall toward the middle (Figs 2 and 3). However, when our fieldwork was undertaken we measured from the 3D model. The rockshelter is 57.53 m, and all the rock art excluding an outlier to the north is within 41.84 m. The site boundaries were delineated by the habitable zone as determined by dripline and height of shelter. The outlier is 7.69 m from the rest of the rock art. The 3D model is accurate because measurements can be taken in straight lines, unlike in the field which are often offset for long distances. Using a laser distance measurer, the rockshelter measured a maximum height of 5 m and a maximum depth of 9.2 m. There is a small cave with two entrances on the northern side of the rockshelter. The panel faces WNW at 300–325°. The highest petroglyph, a human figure, is 3.4 m above the current ground level and the highest petroglyphs are generally 2.5–3.4 m above current ground level when measured with a laser distance measurer.

Survey of surrounding area

We took the old steps to the top of the ridge above the shelter and explored in both directions. There are excellent views to the west and southeast and a number of large boulders on top of the ridge. We examined the more prominent ones of various sizes but no rock markings were found. As well, the rock face outside the shelter proper (with overhang) does not have any petroglyphs. However, we did find a petroglyph 7.9 metres north of the main panel of petroglyphs near the very northern end of the overhang. It is well outside the limits of the original green iron fence from the 1990s but was included in Peralta's record.

We surveyed other caves in the area, using the locals as guides. Another site called Kinahon was reported in the vicinity, but has never been re-located (Barretto-Tesoro 2008; Peralta n.d.).We asked the locals, particularly the elders, if they knew of Kinahon, or any other sites like the Angono petroglyphs, perhaps any painted sites in the area. We also talked casually about their livelihood, what they do with the caves, and anything they wanted to tell us about the area.

Creating the 3D model and post-processing

Across the ~42 metres of engraved wall surface, markers were placed every two metres to delineate arbitrary panels (markers are visible in Fig. 2) for faster processing on the field laptop. A prosumer DSLR, Nikon D7000 was used with an AF-S DX Micro NIKKOR 40 mm f/2.8G fixed lens and a backup mirrorless camera Sony Alpha ILCE-5000 with focal length 44 mm. Tripod and flash were not used. Over 2000 photographs were taken at the engraved rock art site, with at least 60% overlap from at least two perspectives. Markers were placed on or near the panel and included in the photographs, but never over the rock art.

The fine format JPG files created by the camera were grouped into arbitrary 'chunks' representing 2 m length. We processed the chunks the same day on the field laptop with no camera calibration. In the laboratory, photographs were processed in chunks for separate models, but a dense point cloud was also made with all the photographs processed together (Fig. 4; 3D models are available at *http://www.rockartdatabase.com/v2/author/*

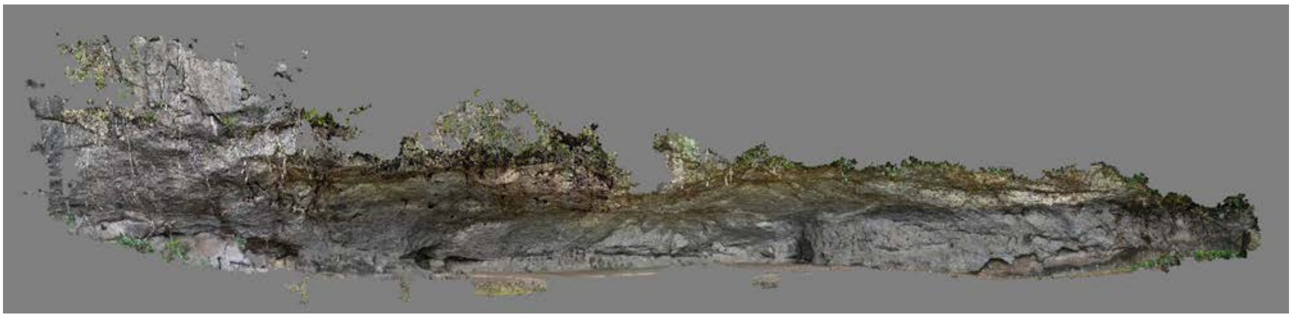

***Figure 4.** Dense point cloud (DPC) of entire site. Source AJ.*

Figure 5. Tools used to experiment: glass and siltstone (left); and chert (right). Source AJ.

andrea-jalandoni/). Agisoft PhotoScan 1.3.1. was used for photogrammetric processing following the method described in detail by Jalandoni et al. (2018). Twenty-one scale bars were used to scale the model to millimetre accuracy. Low-cost structure-from-motion (SfM) 3D modelling is increasingly accepted and utilised in archaeology and particularly rock art research (Chandler and Fryer 2005; Chandler et al. 2007; Sevara and Goldhahn 2011; Willis and Jalandoni 2011; De Reu et al. 2013; Koutsoudis et al. 2013; Plisson and Zotkina 2015; Fritz et al. 2016; Willis et al. 2016; Burton et al. 2017).

The digital elevation models of each chunk, created from the point cloud in Agisoft Photoscan, were imported into ArcMap 10.3. Due to the contour of the rockshelter surface and the conversion from 3D to 2D, the chunks could not be completely aligned (unless accepting distortion). Enhancing the petroglyphs using topographic position index and Hillshade (TPI-HS), digital tracing, and exporting the data to SPSS v.23 followed the procedure elaborated in Jalandoni and Kottermair (in press). The TPI-HS layers and tracings are provided in the Appendix.

Descriptive statistics and cross-tabulation between phase/anthropomorph and certain attributes (superimposed, superimposed over, traced over, 'fingers', 'headgear', cupules, bisect lines and converted geometrics) were calculated to identify possible associations (Table 1). The number of cupules and bisect lines associated with a figure were summarised into present (n>0) and absent (n=0) to meet the conditions of a chi-square test. Chi-square tests are an acceptable method in rock art research (see Lynch and Donahue 1980; Taçon 1989; Jalandoni and Kottermair in press) to ascertain relationships between categorical variables.

The hypotheses used were as follows:
H0: In Angono, phase/anthropomorph and attribute (superimposed, superimposed over, traced over, fingers, headgear, cupules, bisect lines and converted geometrics) are independent of each other.
Ha: In Angono, phase/anthropomorph and attribute are not independent of each other.

Experimentation

The rockshelter was accessed through a guarded ~120 m long tunnel that is cut through the same Guadalupe Tuff as the Angono petroglyphs. The tunnel was oriented east to west and was located ~175 m south of the rockshelter. Measurements were obtained using Google Maps. The walls of the tunnel were covered in graffiti that mimicked the straight lines of some of the engraved figures. We experimented by making sharp incisions using a siltstone, chert and a piece of glass (Fig. 5). Chert and obsidian were recovered from the 1965 Angono excavation, so the glass was used as a proxy for obsidian.

Results and interpretation

How were Angono petroglyphs made?

Peralta (1972: 48) was convinced that no metal was used to make the petroglyphs and therefore the *terminus ante quem* date of the rock art is pre-Metal Age. However, from visual inspection it is easy to imagine some of the sharp incisions being made with metal.

From our experiment in the tunnel, we found it was effortless to make sharp and crisp-edged incisions on the Guadalupe Tuff (Fig. 6). With all the materials used in replication it was fast and easy to make a very deep, straight, incised line like those of the petroglyphs. We estimated the material to be between 1 and 3 on the Mohs hardness scale. While we initially thought some of the incisions had to be made with metal tools, we now believe that they are most likely made with stone. However, metal tools cannot be completely ruled out. Chert and obsidian were both recovered from the 1965 excavation and are very capable of making the straight cuts like metal. Metal tools could also have been used to retouch the rock art in ancient or recent times.

Phase	If figure is determined to be phase 1 or 2
Anthropomorph	If figure is human-like
Superimposed	If the line(s) superimpose on another figure
Superimposed over	If superimposed by another figure
Traced over	If signs of retouching or redirecting
'Fingers'	If appendages are attached or associated with the arms or legs of an anthropomorph
'Headgear'	If an object is attached or associated with the head of an anthropomorph
Cupules	If pecked or pounded rounded pits, holes and cup-like forms (Taçon et al. 1997)
Bisect lines	If line is across the figure
Converted geometrics	If figure is determined to be converted from an earlier geometric form

Table 1. Definition of attributes.

Figure 6. *Experiments of incising Guadalupe Tuff: glass and siltstone (left to right, upper); and chert (lower). Source AJ.*

Petroglyph description: two styles of petroglyph

Peralta recognised that the petroglyphs were not done by one person and that the overlapping style is a product of cultural institution or group (1973: 103–108). However, we propose that the Angono petroglyphs demonstrate two phases of engraving with different cultural traditions. These phases were identified by empirical observation in the field and corroborated with 3D models and enhanced visualisation.

The first phase (phase-1) consisted of 51 geometric shapes, including 11 vulva forms, which make up 28.5% of all figures. The vulva forms are disembodied oval and triangular shapes that resemble (at least to researchers) female genitalia (Fig. 7) (Hays-Gilpin 2012). In Angono, there are figures that fit the description and are diagnosed as such because they have a round or oval indentation and occasionally a line at the bottom. However, they are different from the relief vulva forms at Alab, Bontoc, a site approximately 280 km north of Angono (Jalandoni and Kottermair in press). We acknowledge the ongoing debate about the 'Venus hypothesis' (Bahn 1986, 2006; Nowell and Chang 2014), but we will use the term 'vulva form' for its descriptive simplicity.

There is at least one 'hocker' human-like figure, with limbs shown bent at elbows and knees (see Schuster 1951; Lommel 2001), made in phase-1 (Fig. 7). There is also a deeply pecked and pounded three circle

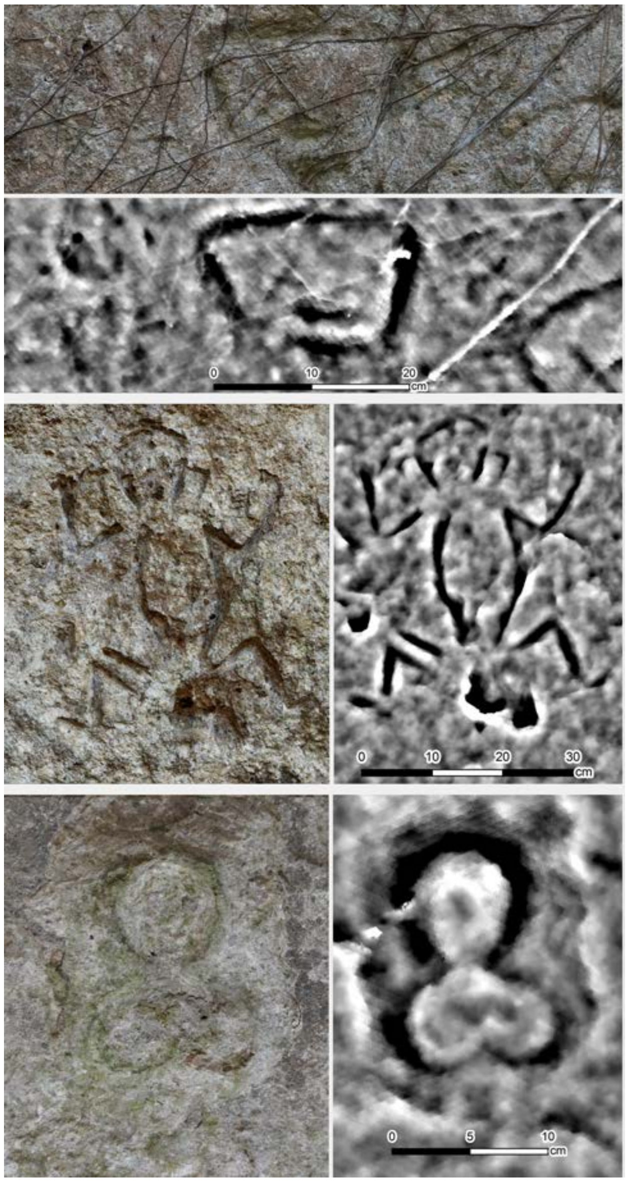

Figure 7. *Examples of phase-1 figures (left: photograph, right: TPI-HS): vulva form (upper); hocker (centre); and three circle relief (lower). Source AJ.*

relief figure (Fig. 7). The relief method is similar to the vulva forms recorded at Alab, Bontoc (Jalandoni and Kottermair in press), but not the three circle design. A few cupules and deep ovals were made by incorporating naturally occurring holes of the rockshelter. We suggest all phase-1 designs were made with stone tools because they appear as pounded, pecked and scraped designs with deep and broad engraved lines and rough edges. In the case of Angono, vulva forms are generally triangular shapes with a bisect line or hole/small cupule near the bottom of the triangle. The vulva form designs are similar to those found in many other parts of the world but most were made by hunter-gatherers (e.g. see Morwood 2002; White et al. 2012; Hampson 2016 for some examples; but note that Easter Island vulva forms were made by Austronesians, see Van Tilburg and Lee 1987). Consequently, we argue hunt-

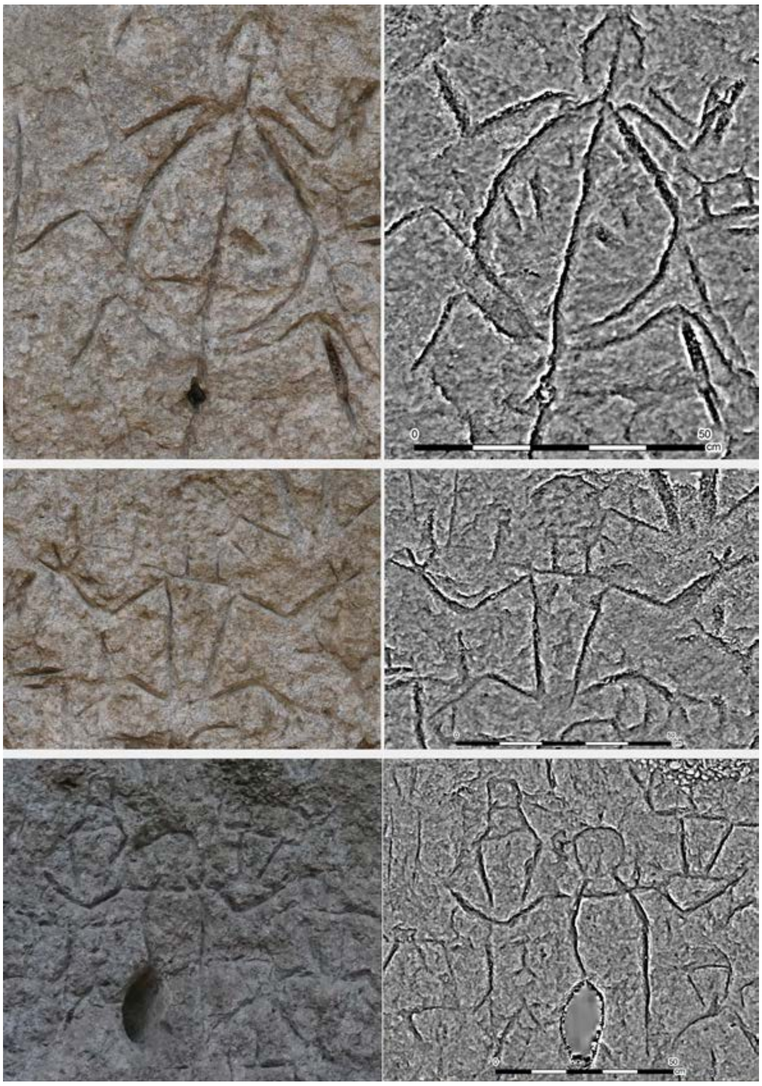

Figure 8. *Examples of phase-2 anthropomorphs (left: photograph, right: TPI-HS): converted vulva form, oval-shaped body (upper); traced over with circular 'headgear' and three fingers and three toes (centre); and two bowling pin bodies with rare superimposition (lower). Scales 50 cm, source AJ.*

er-gatherers most likely were responsible for phase-1.

Peralta interpreted the triangles to be sexual or incomplete zoomorphic figures (1973: 74); however, based on empirical observation, we interpret them to be phase-1 figures that were altered in a second phase (phase-2). There were 128 phase-2 figures, and 53.1% (n=68) of them were converted phase-1 geometrics. Of the 68 converted geometric, 62 (91.2%) were altered into anthropomorphs.

Phase-2 predominantly converted phase-1 geometrics to anthropomorphs by adding appendages, such as thin line arms, and legs, and either thin, thick or fully hollowed out head or torso. Only 6 (9.1%) of the anthropomorphs were not converted phase-1 geometrics. The chi-square test affirmed a likely association between anthropomorph and converted geometric, $\chi 2$ (1, N=179) = 37.062, $p < 0.000$ and a medium effect size (Cramer's V = 0.455) (based on Cohen 1988).

Some features of the anthropomorphs include digits/toes; 18.6% (n=21) had 2 to 3 digits extending from 1 to all 4 appendages (Fig. 8). Also, 13.3% (n=14) were wearing some form of 'headgear', predominantly circular (n=11) (Fig. 8), but also 'horns' (n=2), and one figure has both 'horns' and a rectangular-shaped 'headgear'. Four of the anthropomorphs had a bowling pin shape (Fig. 8), three had oval bodies (Fig. 8), three were holding a curved object, and one had a 'fishtail' for legs.

Overall, phase-2 petroglyphs appear to be much more recent, based on appearance, shape and more refined or reworked edges, as well as thin incised lines. The lines are mostly engraved but not as deep as phase-1 figures. Also, stone tool impact and replication of partial geometric shapes are present. For the most part, second-phase figures might look like they have been made with metal tools, but as explained above, the softness of Guadalupe Tuff makes it just as possible that stone tools were used. Finally, modern graffiti and imitation human figures are visible but they are differentiated from phase-1 and phase-2 because of discrepancies in manner of depiction (style, technique, placement etc.). Graffiti is predominantly confined to the lower section of the rockshelter and in sporadic concentrations (see Appendix).

3D model and enhancement

Peralta (1973) did outstanding work recording the Angono petroglyphs. Unfortunately, he did not have the benefit of technology available today. While his table of categories is laboriously constructed, the majority of the classifications are inevitably erroneous because he could not see the rock art clearly. By enhancing the petroglyphs, more figures can be identified with a higher level of confidence (Jalandoni and Kottermair in press).

Peralta (1973: i–ii) specifies that there are 127 discernible figures, but conceded only 78 could be classified and the remaining 49 were indeterminable due to the method of engraving or erosion. Using the method piloted by one of the author's (AJ), 179 figures that fit the description of phase-1 and phase-2 were recorded. While we identified 101 (129.5%) more determinable figures than Peralta's 78, we do not discount the possibility that some of the petroglyphs we found were added (as graffiti) after his recording in the 1960s and 1970s. However, while Peralta iterates that there are 127 discernible figures, his drawing appears to include at least 149 figures. In addition, we identified more than 40 other figures that do not fit the criteria for phase-1 nor phase-2 and were therefore not counted as part of the 179 figures. They are possibly part of phase-2, but are more likely to be very early graffiti.

Even with generous concessions for differences in opinion, there are still grave disparities between Peralta's record and the one we present. For example, there are undeniable discrepancies in the number of digits recorded. Peralta registered non-existent fingers and toes and failed to document some existing ones. We cannot fault Peralta because some of our interpretation while in the field was also invalidated using the 3D model and GIS enhancement. For instance, initially we interpreted the outlier figure to be phallic, which led us to speculate the phallic figure was purposefully separated from the vulva forms. However, viewing the 3D model of the outlier and verifying it in the field revealed it to be a phase-1 geometric converted into a phase-2 anthropomorph (Fig. 9). Thus we rejected our initial phallic interpretation in favour of an interpretation of a human figure. The 3D model neutralised the discoloration of the rock and allowed the figure to be viewed from different angles, which made the petroglyph more distinct. In another case, what we interpreted to be two triangles in the field was revealed to be an anthropomorph (Fig. 9). There are 46 figures where Peralta's record has additions to the petroglyph, 26 figures with missing elements, and 4 figures with both additional and missing lines.

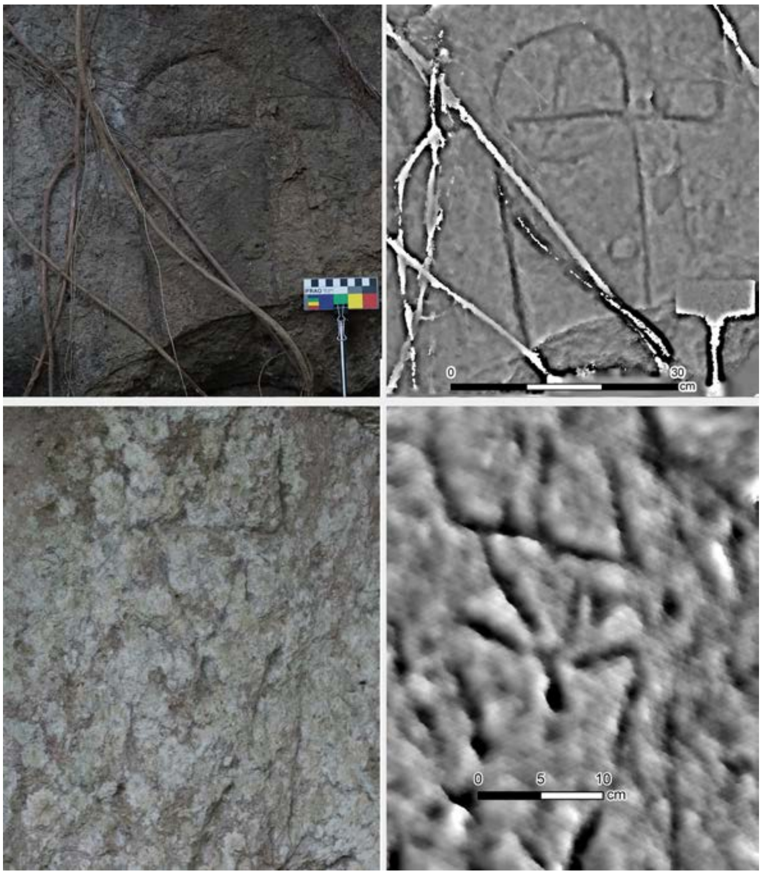

Figure 9. Examples of TPI-HS method (right) enhancing obfuscated rock art (left). In the field, the outlier was interpreted as phallic and revealed to be an anthropomorph (upper), and two triangles were reinterpreted to be an anthropomorph (lower). Scales 30 cm (upper) and 10 cm (lower), source AJ.

There are also 8 figures in Peralta's record that are not visible in our record. As demonstrated in Alab, it is not unusual to have false positives with manual recording (Jalandoni and Kottermair in press). The discoloration of the rock, shadows and other distorting factors can mislead the recorder. The benefit of using the TPI-HS method is that it disregards those distorting factors and highlights differences in elevation. In principle, the TPI-HS method is effective because an engraving is a human-made depression. However, the method does not distinguish between natural and anthropogenic, it is still up to the researchers to interpret.

Who were the artists?

While it has not been published, some archaeologists in the Philippines question the authenticity of the Angono petroglyphs. One of the suggestions is that Carlos V. Francisco, the discoverer of the rock art, made the rock art himself. The suspicion arises because Francisco was a famous and influential artist in his lifetime, even posthumously receiving the highest state honour of *Pambansang Alagad ng Sining ng Pilipinas* (National Artist of the Philippines). However, various lines of evidence suggest the Angono petroglyphs were made prior to the 1960s, including the nature of the phase-1 designs which can also be found at Alab, Bontoc, central Luzon (Jalandoni and Kottermair in press).

The Negritos are Indigenous People (IP) who arrived in the Philippines during the Pleistocene either via land bridges or short watercraft trips (Mulvaney and Kamminga 1999; Turner and Eder 2006). Padilla (2015), using Blumentritt's 1890 and Algue's 1900 data, made a map identifying known Negrito locations during the end of the Spanish Period in the Philippines. It should be noted that the accuracy and comprehensiveness of the data are limited and the Negritos were peripatetic. We used the information from Padilla's map and superimposed it on a map highlighting the location of Angono to see if Negritos were known to be in the area. The results indicate Negritos were in the vicinity of Angono (Fig. 10). While rock paintings by Negritos in Malaysia (Orang Asli) have been well documented (Matthews 1960; Saidin and Taçon 2011; Tan 2014), there are no recorded petroglyph sites made by Negritos. However, as noted above, 'vulva' designs are traditionally attributed to hunter-gatherers, which would make the Negritos the most likely candidates for phase-1.

For the phase-2, the artists are either the Austronesian hunter-gatherers or the guerrillas who camped in the rockshelter during World War II. They are dated

Figure 10. The location of the Angono site combined with the Negrito locations in the Philippines. Source AJ, adapted from Padilla (2015) with the permission of Wayne State University Press.

sometime after phase-1 and before the discovery of the rock art in 1965.

Dating

The age of the petroglyphs has always been an enigma. Progress has been made in uranium-series dating methods for rock art, particularly in Southeast Asia (Aubert et al. 2014). Unfortunately, there are no speleothems to date in the Angono Petroglyph site. The only deposits on the rock and petroglyphs are other mineral salts or efflorescence. The rockshelter was formed in the late Pleistocene or early Holocene (De La Rosa n.d.) and the petroglyphs cannot be older than their canvas. Therefore, the *terminus post quem* for the petroglyphs at Angono would be approximately 11 700 years ago (based on Walker et al. 2009). While the date might not seem constructive, it does rule out the petroglyphs being tens of thousands of years old.

While absolute dating technology for petroglyphs has not made any progress for Angono since the assessment of Peralta (1973), the importance of superimposition should not be overlooked. Van Tilburg and Lee (1987) identified a symbolic stratigraphy of the rock art in Easter Island and proposed that superimposition of new symbols indicates a shift in ideological emphasis. For example, 'vulvas' in Easter Island are considered a late phase and symbolise a replacement of the birdman cult with the fertility cult around 1500 CE (Van Tilburg and Lee 1987). Use and reuse are common in rock art sites around the world. When discussing methods used for dating Arnhem Land rock art, Chippindale and Taçon (1998) noted that over time there were several changes in both the subject and the manners of depiction. In South Africa, Morris (1988) observed that at many sites petroglyphs were superimposed over the course of centuries and ancient rock art is often accompanied with more recent or modern imitations, together with inscriptions and vandalism.

Alterations of both painted and engraved figures, including vulva forms, into new forms is evident in many rock art sites around the world. Phase-1 and phase-2 traditions demonstrate both a change in manufacturing technique and a thematic shift which are significant and time-related. In understanding the stratigraphic sequence of a single panel, it is important that multiple observations can be made (Chippindale and Taçon 1998). At Angono, phase-2 re-use of phase-1 is ubiquitous throughout the site. There were originally 116 phase-1 geometrics and vulva forms, and 68 (58.6%) of them were re-used during phase-2.

It was observed on site that the petroglyphs did not often superimpose, only 13 (7.3%) figures were superimposed and 7 (3.9%) superimposed over another figure. A comparably low percentage of superimposition was also recorded in Alab, Bontoc (Jalandoni and Kottermair in press). However, in Angono retouching was pervasive with 72 (40.2%) figures being traced over. The chi-square test exposed an association between phase and being traced over, $\chi 2$ (1, N=179) = 36.090, $p < 0.000$ and a medium effect size (Cramer's V = 0.467) (based on Cohen 1988). We found 70/128 (54.7%) of phase-2 motifs were traced over versus 2/51 (3.9%) of phase-1.

Site conservation and tourism

The Angono site was first opened to the public in 1989 with an iron fence painted green on a low concrete wall immediately in front of the shelter for protection. To access the site visitors climbed the ridge behind the shelter from the other side and descended down stone steps that led to the northern end. In 1996, the corporation that owns the land, Antipolo Properties Inc. (API), bored a tunnel through the ridge south of

the Angono Rockshelter to improve accessibility (Stanley-Price 1997). Aside from donating the land fronting the rockshelter to the NM, they also continue to landscape the surrounding area and care for the access roads. In 1997, the NM installed a viewing platform. A replacement viewing deck opened in October 2015 after the site was closed for 14 months for renovation. The Angono site is very popular with local Filipinos and tourists; we were told by museum staff that the site receives between 1000 to 1500 visitors each month.

The initial clearing of vegetation exposed the petroglyphs to sunlight and rain and led to increased visitation by birds and people, all of which was thought to have damaged the rock art (Peralta n.d). Even in the 1960s or 1970s, Peralta (n.d.) claimed some of the petroglyphs had already been lost. However, we found no empirical evidence to suggest any petroglyphs have been destroyed. Furthermore, more than animals or biological growths, water is the most serious threat to the petroglyphs (Paterno 1999). Paterno (1999) artificially weathered samples of the rock from the Angono rockshelter and found the petroglyphs are most threatened by moisture filtration that can cause powdering, spalling and flaking.

In 1965, Peralta (1973) already noted graffiti at the site. However, attempting to cast the petroglyphs using lacquer, thinner and plaster applied directly to the rock art was also destructive. The damage from the attempts to clean and cast (see Evangelista et al. 1965; Peralta and Evangelista 1972; Peralta 1973) and 1986 biocide treatment (see Stanley-Price 1997) could not be assessed because the exact chemicals and methods employed were not detailed (Paterno 1999).

Visitor books provide an outlet for visitors to redirect graffiti (Franklin 2011, 2014), but the visitor book in Angono is less likely to be effective because it is safeguarded by the NM staff, therefore visitors are less likely to draw in it. Aside from the constant supervision of the site by staff of the NM, graffiti are also moderated because of the access tunnel to the site. The tunnel where we conducted our materials test has graffiti of names and anthropomorphs, replicating those in the rockshelter. Since the tunnel opening on the rockshelter side is not monitored, it acts as a surrogate visitor book and allows visitors to leave their mark.

Monitoring is especially effective if regular and recurring measurements are made to evaluate the change at a site (Lambert 2007). Now that there is a 3D model of the state of rock art at the Angono rockshelter as of February 2016, it will be easy to monitor any change. Periodically, the site can be recorded and the latest model can be compared with our February 2016 model for change detection. Not only will additional graffiti be exposed but also we will know if we lose any of the figures to natural processes. A 3D model is especially valuable if any of the figures are destroyed. We recommend 3D modelling be a part of every rock art condition assessment and with the ease and cost-effectiveness of SfM photogrammetry this is a feasible approach.

The Guadalupe Tuff is low on Mohs hardness scale, so the material of the tools used to make the Angono designs is still a mystery. Macroscopic 3D recording of petroglyphs has been successful for identifying tool marks, particularly on soft rocks (Plisson and Zotkina 2015; Burton et al. 2017) and could be applicable for the Angono petroglyphs. Future research could include replicating the experiments conducted here with glass and siltstone but recording the before and after with microscope photography to see if any scratch marks are produced.

Conclusion

Marshack (1972) repeatedly emphasised his ground-breaking work on cognitive aspects of Palaeolithic art which could not be done without the aid of a microscope. Likewise, the analysis and interpretation of the Angono petroglyphs are greatly aided by the 3D modelling and GIS enhancement method, TPI-HS. There might always be subjectivity in the recording of rock art because it is an interpretation of what is perceptible to the researcher. However, as we have verified at Angono, elucidating the petroglyphs increases visibility, therefore allowing for a more accurate interpretation that can be verified by others.

In conclusion, there were two pre-1965 phases identified, phase-1 and phase-2, and they differ in both subject and execution. Phase-1 is comprised mostly of geometrics and vulva forms that were pounded, pecked or incised with broad strokes using a stone tool. Phase-2 was a re-use of the figures of phase-1, by altering and adding appendages. The lines of phase-2 are sharper and the edges are crisper than phase-1, but metal tools were not necessarily needed for their production.

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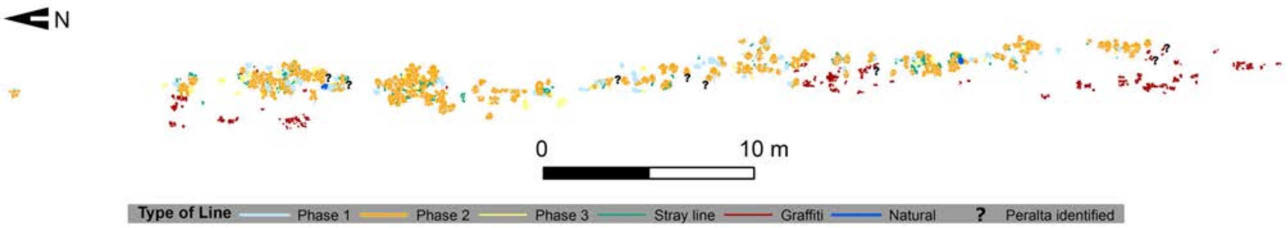
Appendix: Angono digital tracings

The rock art of Angono is spread over a rockshelter too dispersed to display informatively on a single page. Therefore, we divided them into panels organised from north to south starting from the 'outlier'. The panels vary in size to prioritise accurate scaling. The panels were oriented to provide orthogonal views of the rock art. However, since the rock is not a flat surface, there are instances where the figure is skewed. This is more dominant with the few figures on the lower section of a panel where the rockshelter changes slope. However, it also tends to happen in larger panels because there are likely to be more slopes in a larger area. The scales are also visible in panels and account for thin rectangles with square anomalies in the 3D model and derivatives (DEM layer and TPI-HS layer). The tracings are on the TPI-HS background with TPI layer set to 50% transparency.

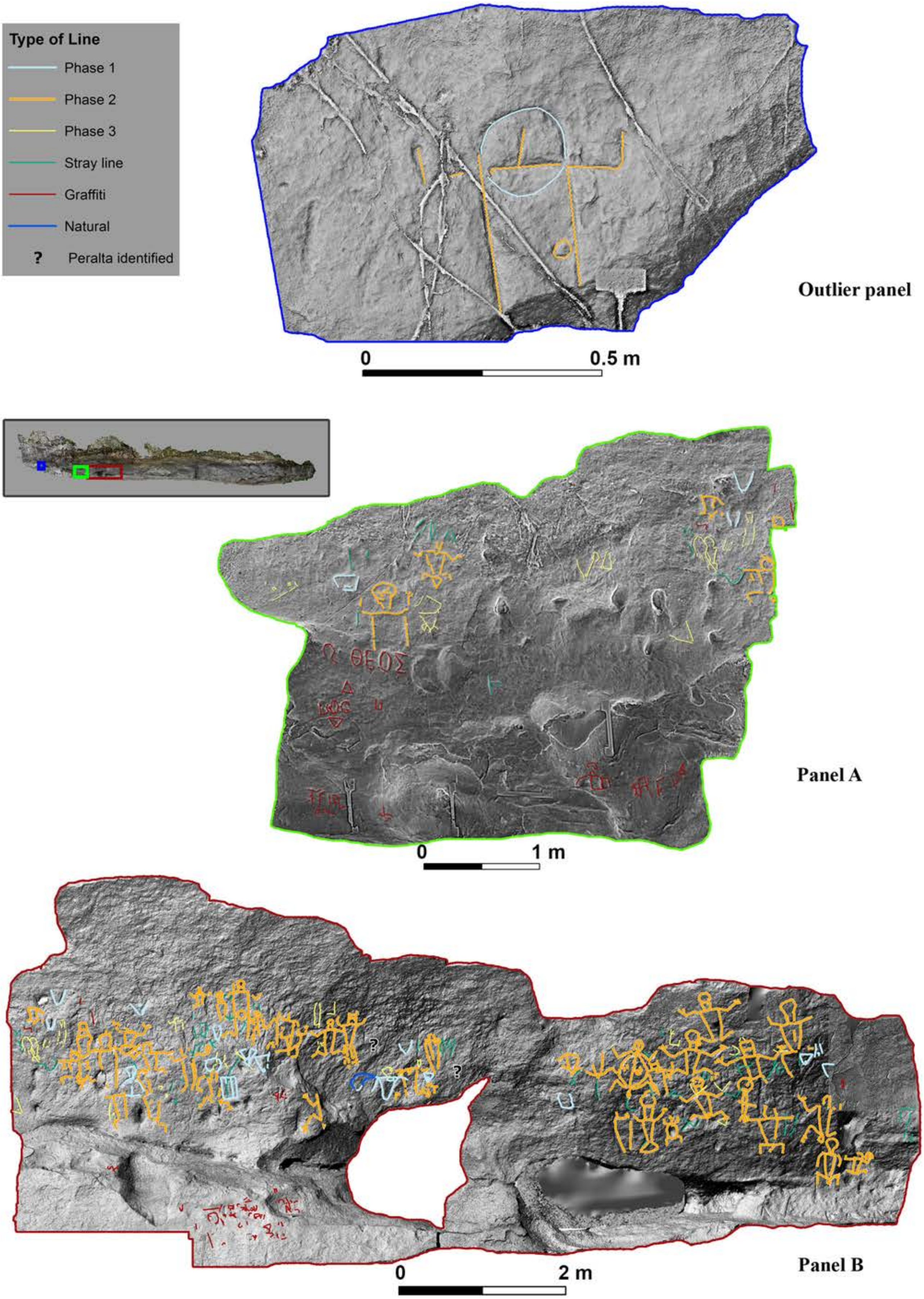
Notes:

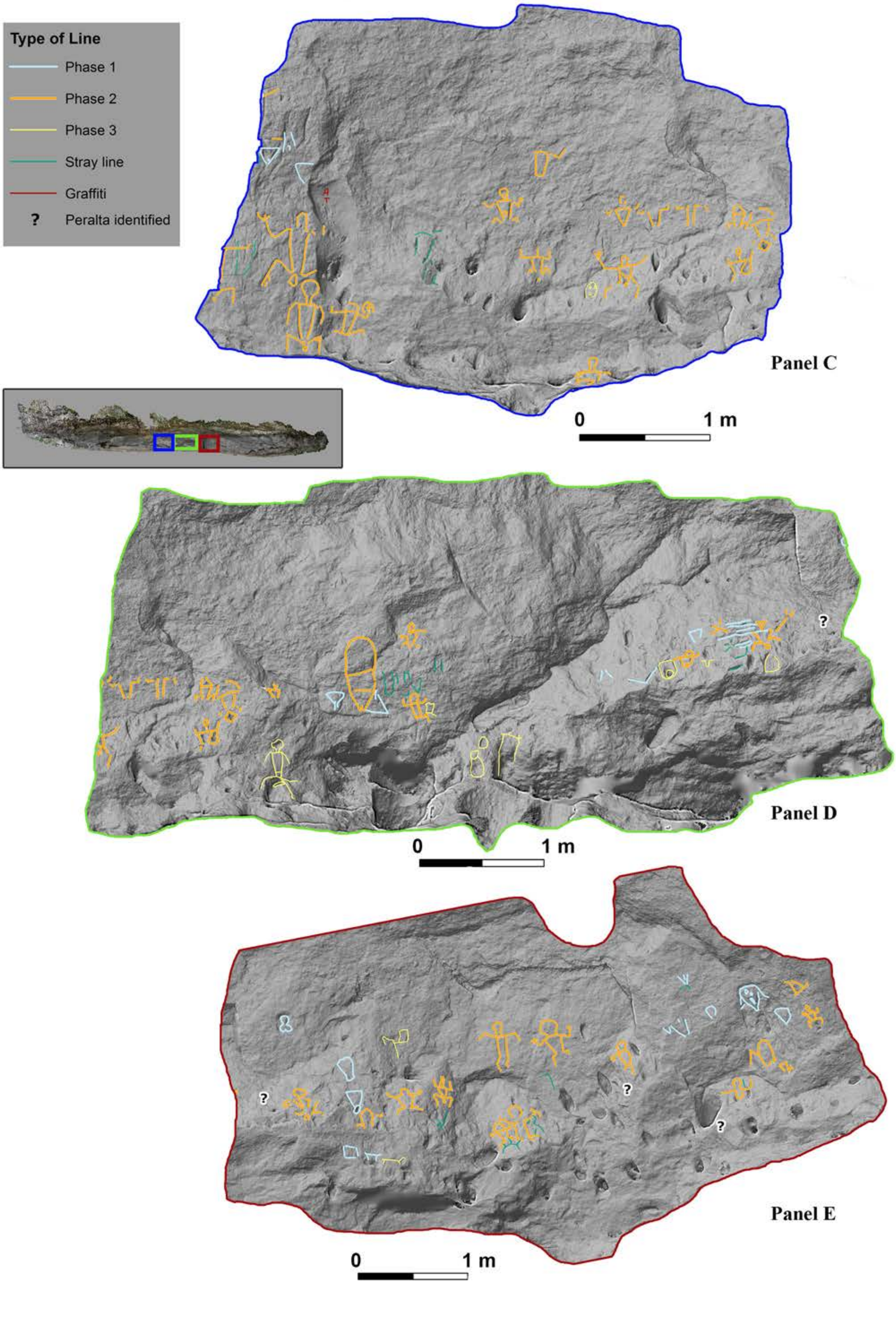
Panel A is the outlier and the rectangular scale visible is an IFRAO scale, 10 cm long.

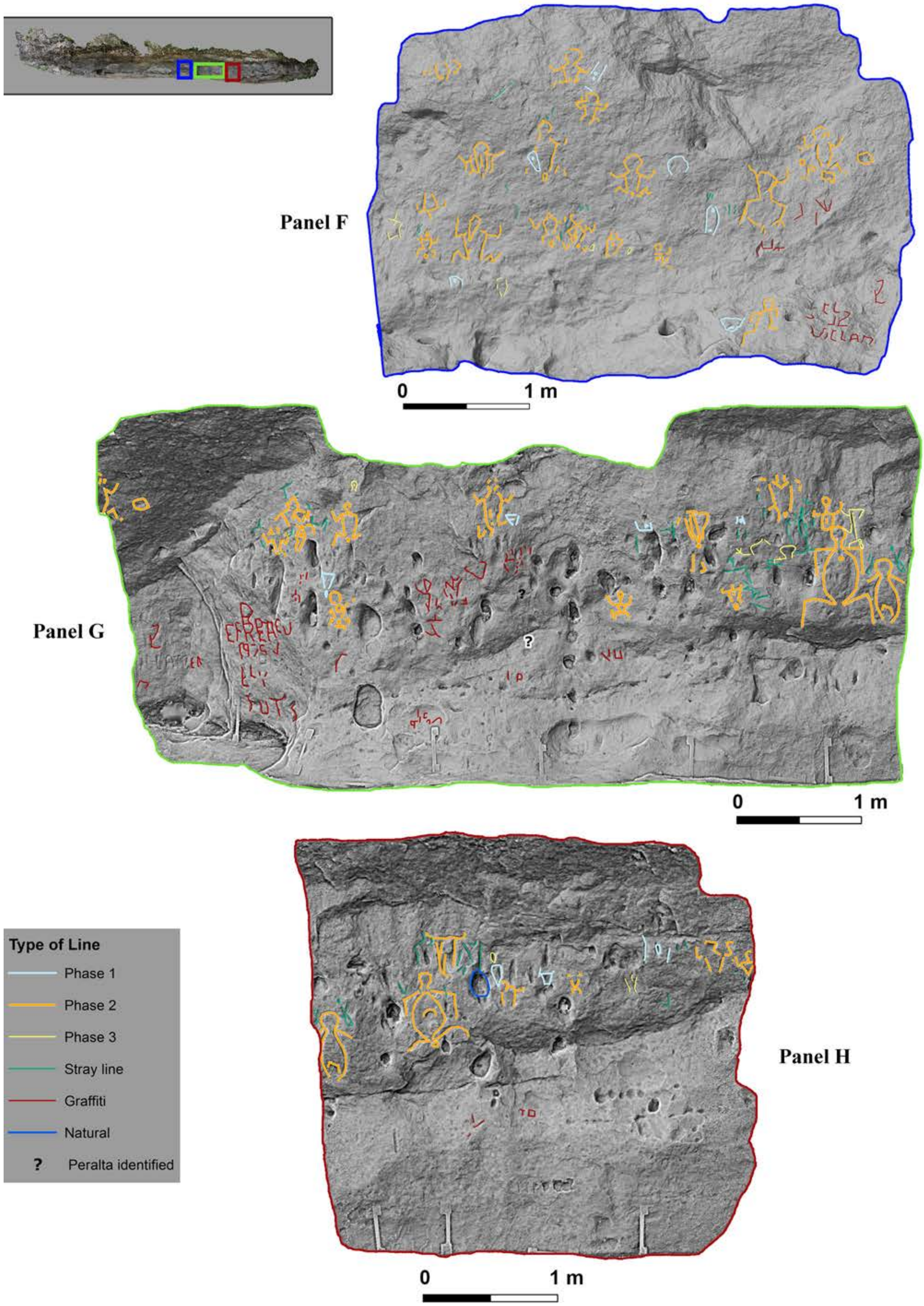
Panel C has a large cavity on the left that is the entrance to a small cave.

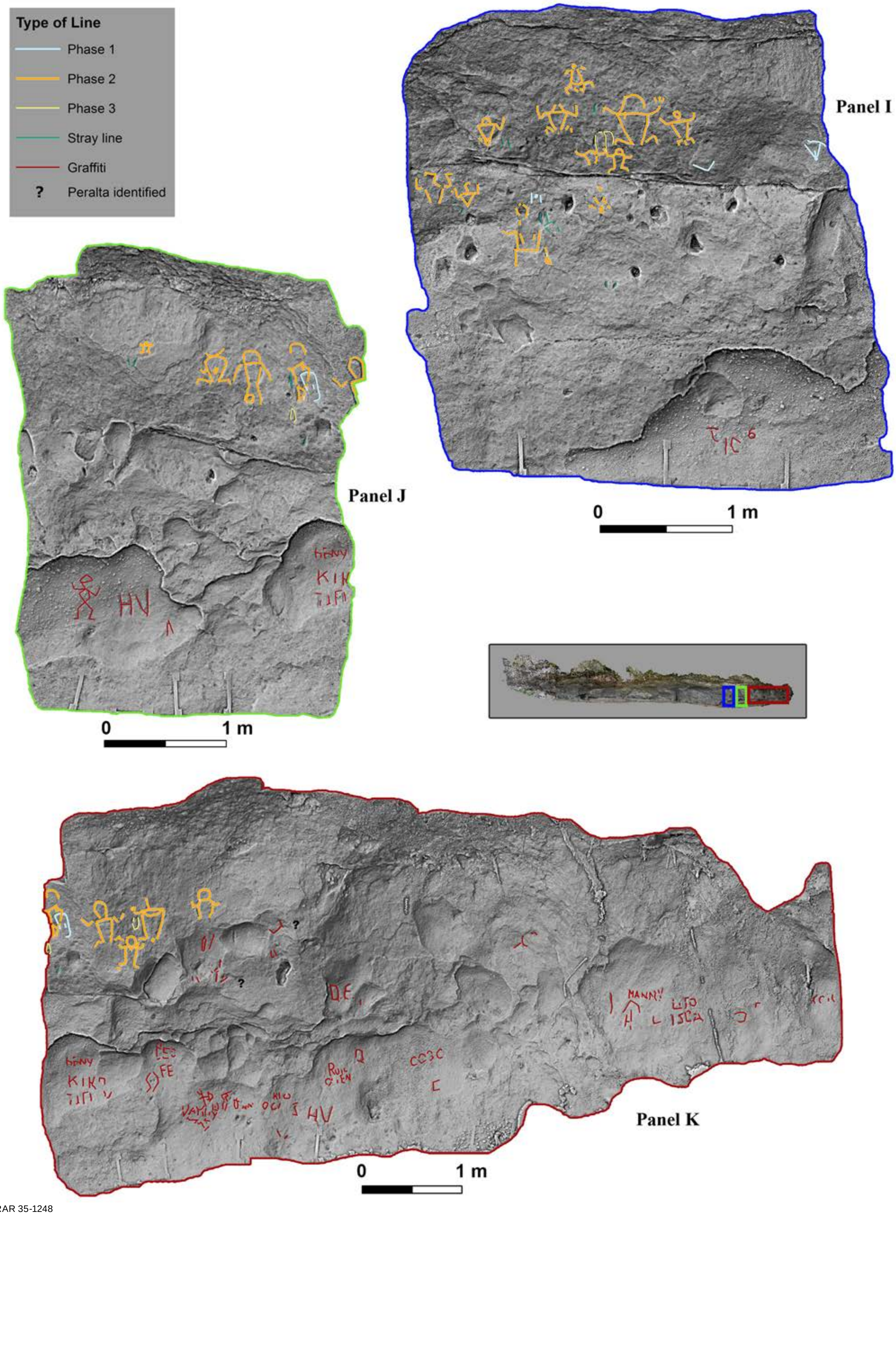


Complete tracing


Type of Line
Phase 1
Phase 2
Phase 3
Stray line
Graffiti
Natural
? Peralta identified
0
0.5 m
Outlier panel
0
1 m
Panel A
0
2 m
Panel B


Type of Line
Phase 1
Phase 2
Phase 3
Stray line
Graffiti
? Peralta identified
Panel C
0 1 m
Panel D
0 1 m
Panel E
0 1 m


Panel F
0
1 m
Panel G
0
1 m
Panel H
0
1 m
Type of Line
Phase 1
Phase 2
Phase 3
Stray line
Graffiti
Natural
? Peralta identified


Type of Line
Phase 1
Phase 2
Phase 3
Stray line
Graffiti
? Peralta identified
Panel I
0 1 m
Panel J
0 1 m
Panel K
0 1 m

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